

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Thematic Classification of Multispectral Image Data
By Use of Digital Film Recorders

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Open-File Report 81- 275

This report is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards. The use of trade names in this report is for descriptive purposes only and does not imply endorsement by the U.S. Geological Survey.

Introduction

Because of the recent advances in digital image processing of multispectral data, optical and combined optical-digital techniques are often considered outmoded. However, as the number and size of remote-sensing data sets increase, the cost limitations of digital computer processing become more pronounced. The problem becomes particularly acute when iterative processing of data for large areas is required, for example, to define spectral characteristics of a geologic target. We have devised a technique to use the transfer characteristic (TC) function of a digital film recorder to define areas of spectral similarity in multispectral image data. The technique provides a means for achieving a parallelepiped classification without additional computer processing of the multispectral data set; different iterations of the film parallelepiped classification can be combined in a color-composite image to facilitate comparison between successive passes. We have used this technique to extract thematic information from band-ratioed Landsat data. Information obtained by this technique compares well with the information present in a color-ratio composite image but this technique excels in precise extraction of the selected theme. The method provides a simple and cost-effective means for the identification of spectrally similar areas in multispectral image data.

Description of technique

Digital film recorders are used in image processing to produce film products from computer compatible tapes. Images are produced at the U.S. Geological Survey National Center, Reston, Va., by use of the Optronics P-1500 Photomation system. In this system, digital numbers (DNs) on the tape between 0 and 255 are converted to analog signals that modulate a light-emitting diode (LED).

Certain transformations of the digital data can be performed directly as the film is being written. A transfer characteristic (TC) function allows the

user to specify any output gray level on film for any input DN on the tape. The TC function is a 256-position look-up table consisting of integer values that correspond to the output gray scale range of 0 (black) to 255 (transparent). The star (*) convention, in the form M*N, can be used when writing a TC function to denote an array value N which is assigned to occur in M successive positions. For instance; a TC function written "10*0 59*255 187*0" specifies that DNs in the first 10 positions in the array, input DNs 0 to 9, be displayed as black. DNs in next 59 positions, input DNs 10 to 68, will be shown as transparent and DNs in the last 187 positions, input DNs 69 to 255, will appear black.

A supervised parallelepiped classification can be done directly on a digital film recorder such as the Optronics by use of the TC functions. Parallelepiped classification is based on the selection of a range of values that bracket a category in each of the channels of data. By use of a TC function that brackets the input DNs of interest, picture elements (pixels) that display a given spectral value or range in any single channel of data can be isolated. For multichannel classifications, it is necessary to specify that pixels which fall within the bracketed DN range be made to appear transparent. Co-registration of data onto a single piece of film for successive channels in a category is possible by specifying the exact same starting point for each channel of data of the same image area.

Only one parallelepiped category at a time can be isolated by use of this film recorder technique. Additional categories must be isolated in separate runs through the data. Successive iterations of the classification can be color coded by use of a color-additive viewer or diazo film to aid comparison between the iterations. These color-coded composites are also useful for defining pixels that may occur in more than one category.

Application of technique

A color-ratio composite (CRC) image from Landsat multispectral scanner (MSS) data was used to map the distribution of ferric-iron-bearing rocks as possible indicators of hydrothermal alteration in the Walker Lake area of Nevada (Rowan and others, 1980). This image was produced by use of the following color ratio-image combinations: cyan for MSS 4/5, yellow for MSS 4/6, and magenta for MSS 6/7. Areas that show strong ferric-iron absorption have low DNs in both the 4/5 and 4/6 band ratios and appear as shades of green or brown on the CRC image (Rowan and others, 1974). A part of the CRC image used in this study is shown by Goetz and Rowan (in press).

We have used film recorder TC functions to extract band-ratio DNs associated with the green and brown colors seen in a CRC image covering a part of the Walker Lake quadrangle. Means and standard deviations were calculated for 12 targets within the scene. Initial definition of the lower and upper DN boundary values was based on the spread of the means in each band ratio (table 1).

Table 1. Boundary values and transfer characteristic functions used for parallelepiped classification of color-ratio composite image.

	<u>Band Ratio</u>	<u>Lower/Upper DN Values</u>		<u>TC function</u>
Initial	4/5	10	68	10*0 59*255 187*0
	4/6	17	65	17*0 49*255 190*0
Final	4/5	0	68	69*255 187*0
	4/6	0	65	66*255 190*0

Comparison of the initial film parallelepiped classification with the CRC image revealed that a significant number of green and brown pixels were not extracted. Therefore, reasoning that only the darkest greens or browns will exhibit the lowest DNs in both the 4/5 and 4/6 ratios, we expanded the classification parameters to include input DN 0. Figure 1 shows the results of this

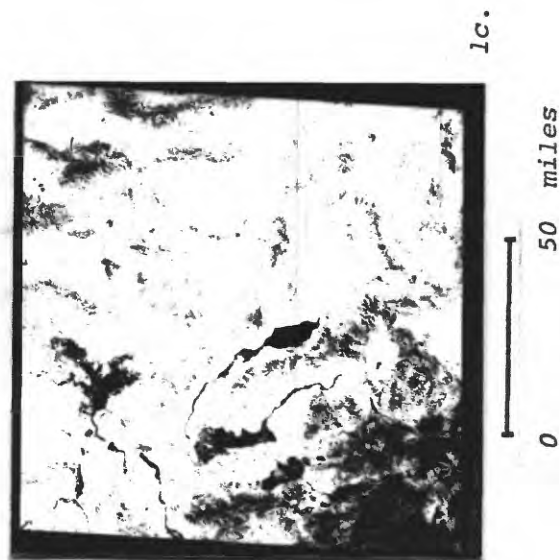
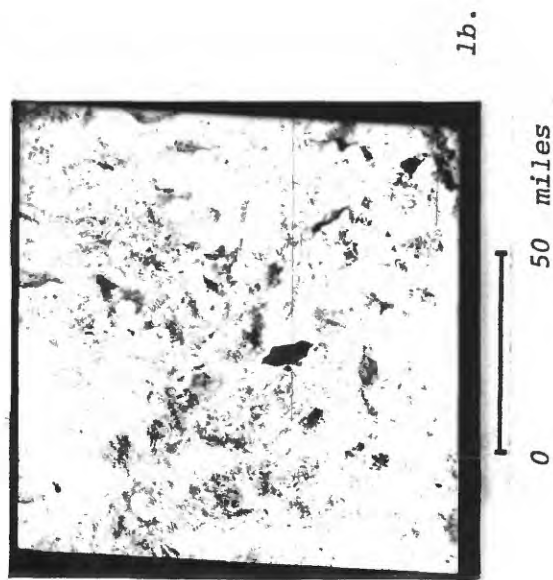
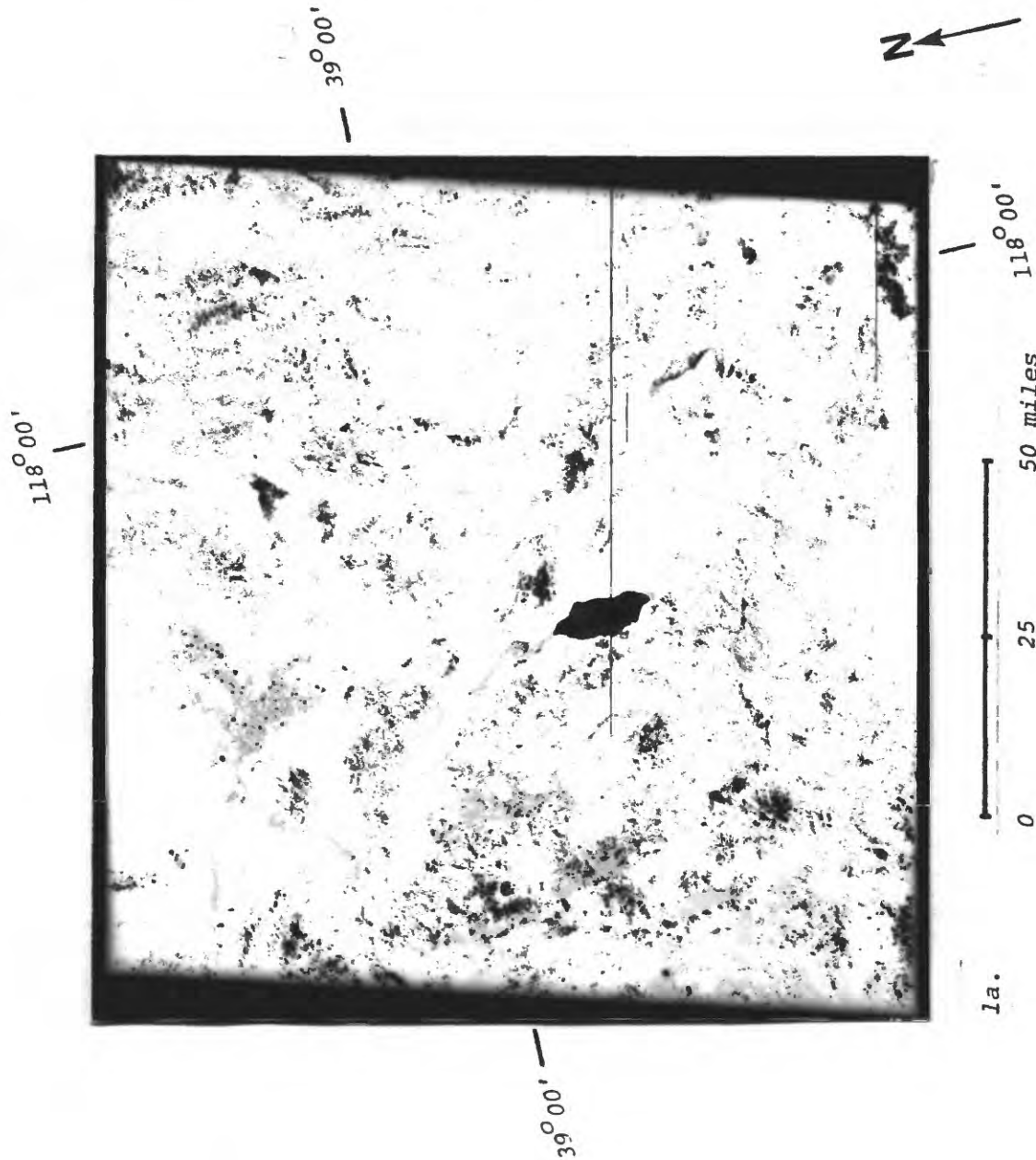


Figure 1. Parallelepiped classification of ferric-iron-bearing materials in the Walker Lake area of Nevada. In figure 1a, ferric-iron-bearing materials appear black on this digitally overlain contact print. Lighter gray shade represents pixels which were extracted in only one band ratio. Figures 1b and 1c show the pixels which were extracted in the 4/5 and 4/6 band ratios, respectively. Pixels which are black in both figures 1b and 1c appear black in figure 1a. Note bit slips at center and lower right of image. Landsat image # 1415-18045.

parallelepiped classification. In figure 1a, areas which exhibit significant ferric-iron absorption appear black on this contact print. The Lighter gray shade indicates pixels that were extracted in only one band ratio. Figures 1b and 1c show the pixels that were extracted in the 4/5 and 4/6 ratios, respectively, and can be used to define the origin of the lighter gray shade seen in figure 1a. The origin of the lighter gray shade could also be defined by displaying each channel as a unique color on diazo film or in a color-additive viewer. Pixels that were extracted in both channels will appear as a unique color combination.

Comparison of this classification with the CRC image showed a much stronger correlation than was previously obtained with the iteration which used a narrower DN range in the 4/5 and 4/6 band ratios. Notably, in the lower left corner of figure 1a, which represents an area where vegetative cover is substantial, some pixels were identified which were not readily discernible in the CRC image.

Conclusions

Parallelepiped classification using TC functions provides a simple and cost-effective means for the thematic extraction of multispectral image data. Although this technique does not permit the extraction of fine differences in DNs possible with maximum likelihood or euclidean distance classifiers, computer processing costs are considerably reduced because iterative experimentation can be done directly on the film recorder. Accurate results are easily obtained by successive iterations if the analyst has a knowledge of the spectral characteristics of the materials in question.

References

Goetz, A.F.H., and Rowan, L.C., 1981, Geologic remote sensing: Science, in press.

Rowan, L.C., Krohn, M.D., and Purdy, T.L., 1980, Generalized map of occurrences of limonitic rocks in the Walker Lake 1° by 2° quadrangle, Nevada-California: U.S. Geological Survey Open-File Report 80-232, 1 sheet, scale 1:250,000.

Rowan, L.C., Wetlaufer, P.H., Goetz, A.F.H., Billingsley, F.C., and Stewart, J.H., 1974, Discrimination of rock types and detection of hydrothermally altered areas in south-central Nevada by the use of computer-enhanced ERTS images: U.S. Geological Survey Professional Paper 883, 35 p.